Relocatable Models Development and Evaluation

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LONG-TERM GOALS

To develop, test, demonstrate and evaluate robust, user-friendly, relocatable ocean models for use in nowcast/forecast systems on tactical scales. Models developed and tested in this 6.2 program and transitioned into the 6.4 Small Scale Oceanography program for advanced development and testing and then for final evaluation under near real time operational conditions.

OBJECTIVES

The objective of this project is to develop a robust globally relocatable ocean model and forecast system for U.S. Navy product enhancement. This will be done by determining the important issues that affect the relocatability of an ocean model, in both deep and shallow areas of the global ocean that are of Navy interest and addressing them individually. Although the issue of relocatability has been studied using simple barotropic ocean models (Preller et al., 2000 and Hubbert et al., 2000) for tide/surge prediction , the complexity of the problem increases dramatically when the ocean model is fully baroclinic. Problems such as model initialization, grid set up (both horizontal and vertical), adequate bathymetry and coastline data bases, boundary conditions, data assimilation, robustness of the model and user-friendliness are all key issues that will be addressed in this project. Once an appropriate model is developed and tested in regions of Navy interest, it is transitioned into the U.S. Navy's 6.4 programs for advanced developmental testing before transition into operations, the ultimate goal of the project.

APPROACH

The approach used in this project is to address key issues for model relocatability one by one and to build on existing work that has been done in the area of relocatable ocean models. Based on operational needs and lessons learned from a baseline capability using a relocatable Princeton Ocean Model, several key issues stand out as requiring further work in order to develop "a truly robust", relocatable system. These issues are the setup of the model grid (both horizontal and vertical), model topography, open boundary conditions (including tides) and model coupling, model initialization, data assimilation and user-friendliness of the relocatability of the system. Several different oceanographic

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14. ABSTRACT
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areas will be used to study these issues. Initial work will be done in both the eastern and western Pacific Ocean, representing areas of Navy interest and will progress to other locations representing varying dynamic and thermodynamic conditions. The project will build from the Princeton Ocean model codes to more flexible codes such as the NRL Coastal Ocean Model (NCOM) or other appropriate codes. The project will also build on simple data assimilation techniques such as "incremental adjustment" to other techniques that meet the operational needs of flexibility and computational limitation.

Key individuals working on this project are: Dr. Dong Shan Ko, code development, data base upgrade, data assimilation, Paul Martin, providing improvements and expert guidance in the running of NCOM codes. Shelley Riedlinger runs the EAS model testing.

WORK COMPLETED

The NAVO DBDB5 ocean topography has been used in the early testing of relocatable ocean models. However, we found that in many regions the model topography did not match the coastline. For a more accurate and easy setup of a relocatable ocean model in any region of Navy interest, we determined that it was necessary to have a uniform, high resolution, gridded global topography data set with a matched coastline. A 2-min global topography (NRL DBDB2) has been developed based on the NAVO DBDBV data base and other topography data sets. The DBDBV, on 5-min grid, was interpolated to 2-min grid and extended to cover the Arctic and Antarctic region. The higher resolution DBDBV topography data sets and Sandwell data were included to form "one" uniform topography data set. This 2-min topography was edited to match a high resolution coastline data set derived from GMT. To accomplish the editing, an interactive topography editor was developed and used. This editor has been provided to several other modeling projects for model topography editing. The first version of the NRL DBDB2 has been completed and applied to setup the model topography for the Northern South China Sea Nowcast/Forecast system (NSCSNFS) and the 1/16 degree East Asian Sea model. It has also been provided to and used by the relocatable MODAS/POM system used by the Navy. This first version of NRL DBDB2 has been further edited to improve the matching of the coastline. Other gridded high resolution topography data sets have been collected and will be added into the updated version of NRL DBDB2 in the coming year.

This NSCS model has been running under operational conditions (referred to as a "Beta Test") where a daily 72-hour forecast is made by a certain time each day. This forecast includes forcing the model with Navy operational products (NOGAPS) such as heat "fluxes" wind stresses "and air pressure" and assimilating operational MODAS data into the system to do a nowcast/forecast in real-time. This Northern South China Sea Nowcast/Forecast (NSCSNFS) has been running since March 1, 2000. The nowcast/forecast fields have been provided to ONR supported ASIAEX participants over the Internet.

To provide the open boundary condition for NSCSNFS and other projects focusing on operational applications, we have maintained and kept updated the NPACNFS. It has been run at NRL in a Beta Test mode, applying real-time operational data, since January 1, 2000 without major interruption. This system has been evaluated against TOGA Tau observations in the equatorial region and shown to be an improvement over the MODAS synthetics produced for the region of the TOGA Tau array. NPACNFS nowcast fields have been requested by and provided to several groups for research and for operational use (Hydroqual, U. of Miami, U. of Delaware).

In addition, we are working with the ONR funded Expert Systems Team. During this year, we provided them with our codes, successfully applied to the POM model for 4th order advection and a modified Smagorinski viscosity and diffusion scheme.

During this year we did several studies model derived transport in the Sea of Japan to observation. Both the NCOM EAS model and the North Pacific POM model were used. In addition we compared transports through various straits in the EAS model to observation. The purpose of this study was to determine if these models are capable of deriving the observed general circulation of the region.

In addition, we worked with several of the PI's of the ONR funded JES project and provided them with initialization fields, boundary conditions and MCSST data for their Japan/East Sea models.

Results from several experiments performed last year (using MODAS temperature, salinity and geostrophic velocities) showed that a large scale ocean model is needed to provide boundary conditions for a truly globally relocatable model. A one way coupling scheme has been developed to take advantage of the availability of fully 3-D large scale model fields for the open boundary conditions. The coupling scheme has been tested and some sensitivity studies performed with regional POM models set up for the NSCSNFS and the EAS model coupled to a north pacific POM. In addition, the EAS NCOM model has been coupled to a larger scale NCOM model in a similar manner.

RESULTS

To test initialization schemes, we have performed two sets of experiments using both the MODAS and large scale model (NPACNFS) "temperature and salinity" fields to cold start a regional (1/24 degree) Northern South China Sea (NSCS) model. Once the model is started it continuously assimilates the data. According to the results we found that the preferred method would be to initialize the model with fields from a large scale model. We did find, however, that differences in the topography between the large scale model and the regional model generated errors due to interpolation/extrapolation of the fields and caused instability in the model requiring a reduced time step to prevent this problem. These are issues that must be resolved if these models are to be truly globally relocatable and nested within a larger scale ocean model as in the case of the COAMPS applications.

The results from the NSCSNFS are being evaluated using ASIAEX data gathered during a field experiment this past April. This work is being done collaboratively with ASIAEX researchers (David Chapman and Glenn Gawarkiewicz, WHOI and David Tang of Taiwan). This test is proving to be a particularly interesting one as even minor variations on the flow through the Luzon Strait have a major effect on the circulation patterns that the model generates in the northern South China Sea. The model derived circulation is shown to be very sensitive to the coupling scheme and the intensity of the data assimilation. This work is on going and should be completed in the next fiscal year.

Evaluation of both the EAS and NPAC models against published, observed transports through a number of the straits of the western pacific show that the modeled transports fall within the observed limits. Figure 1 shows an example of transport from the EAS model from 1996-2000 for the inflow/outflow straits of the Japan/East Sea. These values all fall within the observed estimates of transports for these straits.

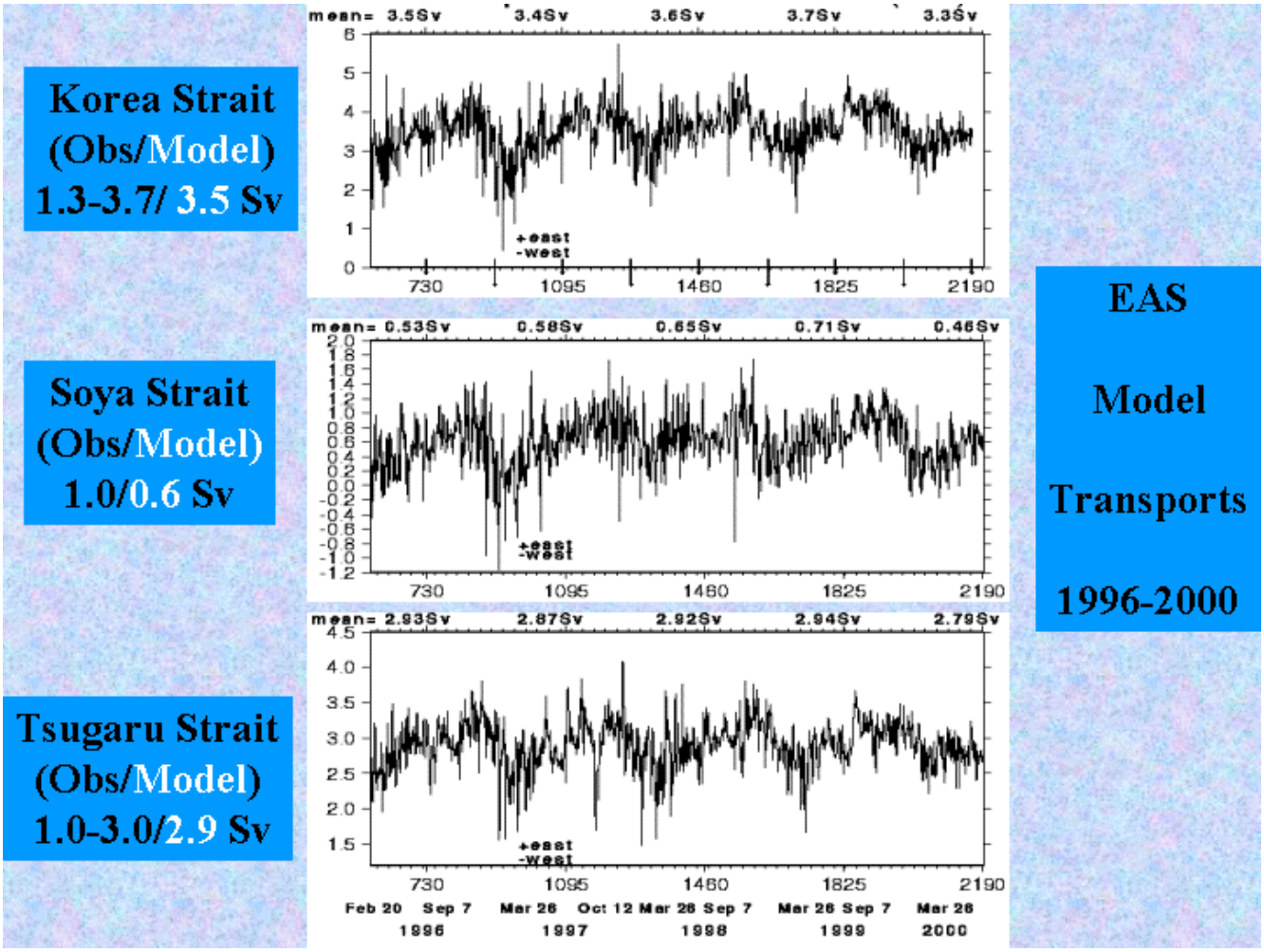

Figure 1. The EAS -year model time series of transport through the Korea, Soya and Tsugaru Straits. The mean transport for these five years, compared to observations, shows that the modeled transport fits within the limits of the observed transports.

Additional evaluations were carried out in detail in the Tsushima straits based on a year long data set from bottom mounted ADCP's obtained by NRL. High frequency variability of the order of synoptic scale events agrees very well with the observations indicating that the forcing driving these models (NOGAPS) is qualitatively accurate. However, the intensity of this variability is biased low in the models.

IMPACT/APPLICATIONS

The impact of this project is to improve the Navy's baseline capability in relocatable global ocean forecasting. We have identified key problem areas and have begun to work on improved techniques for dealing with these problems. Output from this project will transition into operations through the SPAWARS 6.4 Small Scale Oceanography project and then will be used to upgrade the Navy's capability in global ocean prediction via the use of relocatable models. The improvement of the bathymetry and coastline matching data bases this year has been used by other Navy modeling efforts.

The "beta test" for the northern South China Sea, NSCSNFS, shows the operational capabilities of the techniques developed in this project.

TRANSITIONS

There have been no official transitions yet into the 6.4 SPAWAR project.

RELATED PROJECTS

NRL 6.1 LINKS project. Greg Jacob PI. Looks at the interaction of the three Western Pacific marginal seas

SPAWAR 6.4 Small Scale Oceanography project. Tests coastal ocean models in a real time forecasting scenario before they are delivered into operations.

ONR funded COAMPS project.

ONR funded ASIAEX project.

ONR funded JES project

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PUBLICATIONS

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PATENTS